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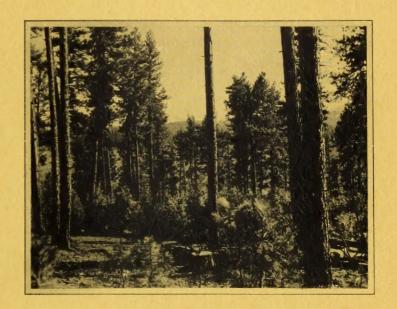
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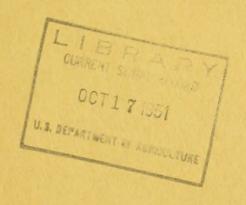


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GROWTH TABLES FOR SELECTIVELY-CUT PONDEROSA PINE IN WESTERN MONTANA

Arthur L. Roe





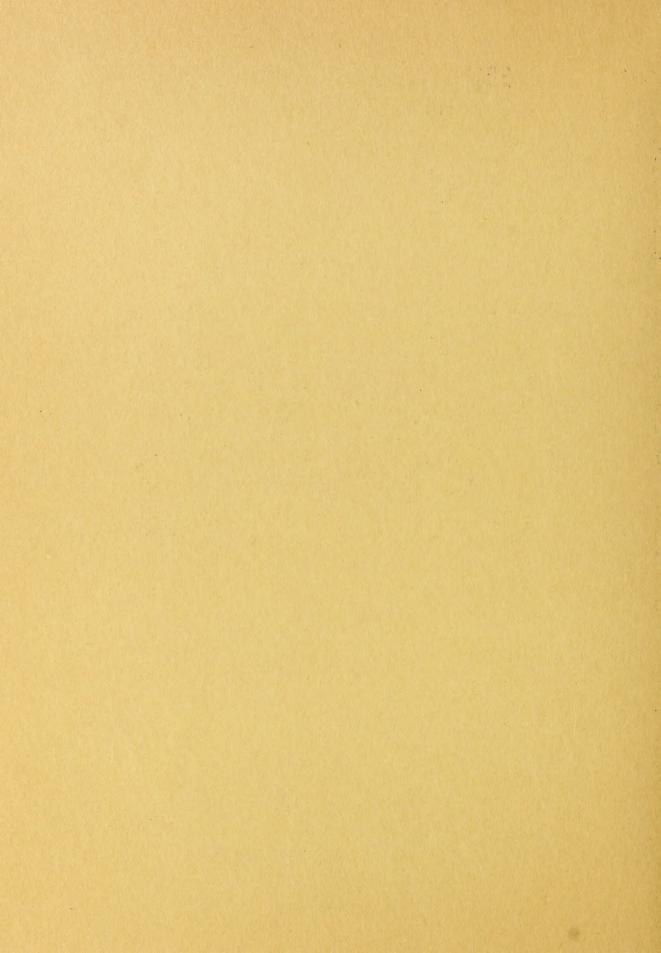
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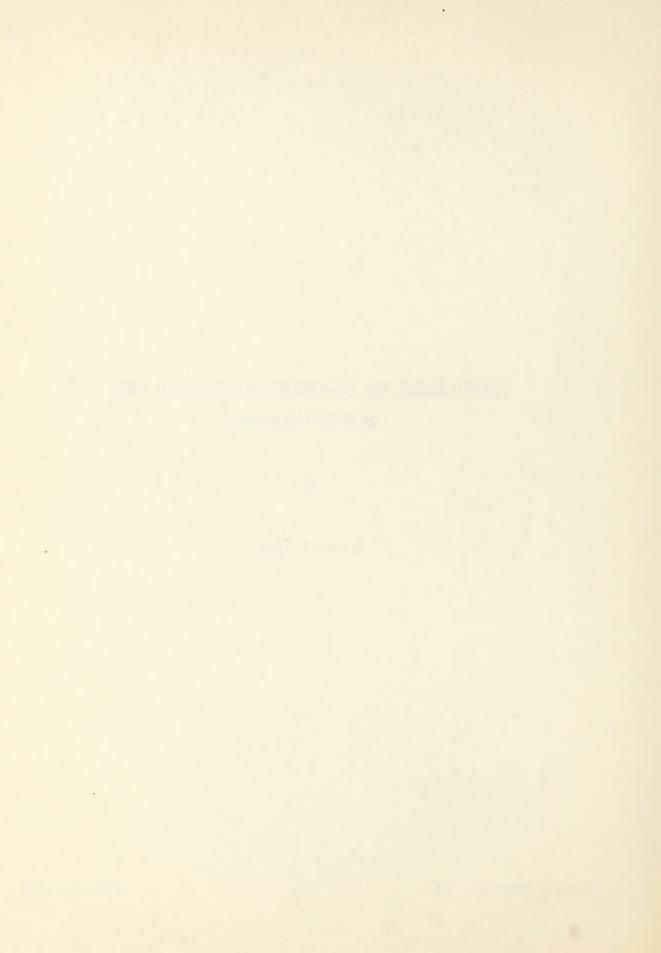
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GROWTH TABLES FOR SELECTIVELY-CUT PONDEROSA PINE IN WESTERN MONTANA

by

Arthur L. Roe



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GROWTH TABLES FOR SELECTIVELY-CUT PONDEROSA PINE

IN WESTERN MONTANA

by

Arthur L. Roe 1/

INTRODUCTION

A study of cut-over ponderosa pine stands in western Montana was made in 1947 in answer to forest managers' requests for ways to predict growth of selectively-cut ponderosa pine timber. Growth responses to different intensities of cutting were analyzed on 60 half-acre temporary sample plots. Age of cutting varied from 5 to 50 years.

From the data obtained, a set of yield tables has been developed for predicting growth of residual trees after logging. The eight growth tables, and methods for their use, are the subject of this report. They are presented on pages 6 to 13. Two kinds of estimates can be made from these tables:

- A general estimate of growth of residual stands on areas containing typical, or average, conditions, to be used principally for broad planning purposes.
- A more precise prediction of the growth of residual stands which includes adjustments for stand competition, site index, and maturity.

HOW TO USE THE TABLES TO PREDICT BOARD-FOOT GROWTH IN CUT-OVER STANDS

GENERAL ESTIMATES

Growth may be estimated as an average figure which will be applicable to average or typical residual stands. Tables 1, 2, and 3 show average volume of residual trees by reserve stand classes up to 50 years after cutting by five-year intervals and site classes. The volumes given are net because mortality has been deducted. Table 1 represents growth estimates for typical or average site class conditions on cut-over areas

^{1/} Division of Forest Management Research.

in western Montana. Tables 2 and 3 show values for site classes IV and V, respectively. To convert the values found in these tables to other site classes, use a 12-percent adjustment factor between site classes. For example, the values found in the site class IV tables when multiplied by 112 percent will be converted to corresponding values for site class III.

The board-foot volume of the reserve stand (trees 10 inches d.b.h. and larger at logging) and site class are the only stand statistics needed in order to use tables 1, 2, and 3. Site classification tables are presented in appendix tables 1 and 2. For example, assume that selective cutting in a ponderosa pine stand averaging site class IV left a reserve stand of 4500 board feet per acre and that the predicted volume of this stand in 30 years is required. The average volume of the residual stand 30 years later would be found as follows: (1) enter table 2 at the 4500 board-foot reserve stand class (interpolate between 4,000 and 5,000 board feet); (2) read the values in the 30-year column. The volume will be 6920 board feet 30 years after logging, representing a net growth of 2420 board feet (6920 bd. ft. - 4500 bd. ft.) in 30 years, or 80.7 board feet periodic annual growth. Ingrowth must be computed independently because it has not been included in these tables.

ADJUSTING GROWTH ESTIMATES FOR ADDITIONAL VARIABLES

To refine the growth prediction, greater knowledge is required concerning the reserve stand. The following information will be needed:

- A stand table of the residual trees in the l-inch d.b.h. class and larger.
- 2. Basal area of the reserve stand 9.6 inches d.b.h. and larger.
- 3. Site index (height in feet of the average dominant and codominant trees at 100 years). See appendix tables 1 and 2.
- 4. Age of residual trees obtained by taking a weighted average of Keen age classes of sample residual trees.

After basal area has been derived from the stand table, summarize the survey data from the cut-over stand and compute growth as shown in the following example:

Reserve stand data:

- 1. Volume 5000 board feet
- 2. Basal area 50 square feet
- 3. Site index 70 feet at 100 years (Site Class V)
- 4. Keen age 2.6
- 5. Cutting cycle 35 years

Growth compilation:

- 1. Derive gross growth by reading from table 4 for the correct basal area (50) and cutting cycle (35). In this instance, gross growth is 4850 board feet. Interpolate when values are intermediate to those shown in the table.
- 2. Obtain a correction factor (94 percent) for age (2.6) and site index (70) from table 5. This reduces growth to 4559 board feet (4850 X 0.94).
- 3. Take out mortality with the 15 percent average found in the study. 4559 (.15 X 4559) or 4559 X 0.85 = 3875 board feet. This is net growth of the residual trees. In case the user of the table has at hand a more exact mortality correction factor for his particular stand, it should be used instead of the 15 percent average.
- 4. Sum the reserve stand volume and net growth to obtain net volume of the residual trees at the end of the cutting cycle or 5000 * 3875 = 8875 board feet per acre. Periodic annual growth is 3875/35 = 111 board feet.
- 5. Set up a stand table for determination of ingrowth, using field survey data as shown below:

D.B.H. class in inches	Trees per Ponderosa pine (Number)	acre Douglas-fir (Number)
3	ose das	ONC COS
4		□
5	.19	2.75
6	comm right	2.17
7	•37	1.90
8	dies CDD	1.28
9	.92	.83
Total	1.48	8.93

Compute ingrowth from tables 6, 7, and 8 and the stand table prepared in step 5. Tables 6, 7, and 8 show the board-foot volume of pole size trees by five-year intervals after logging. In our problem, both ponderosa pine in site class V and Douglas-fir are present. Therefore, values for the solution are taken from table 7 for ponderosa pine and from table 8 for Douglas-fir. Values, read from the proper diameter class and five-year interval in the table, should be multiplied by the number of trees in the corresponding diameter class in the stand table. Thus, in the example there is 0.37 ponderosa pine tree per acre in the 7-inch d.b.h. class. A volume of 41 board feet is shown in table 7 for the volume of a 7-inch tree 35 years after logging. This volume multiplied by the number of trees per acre in the stand table will then give the volume per acre (41 X .37 = 15.17 bd. ft.). A tabulation like the following will be the result when volumes for the other diameter classes have been computed.

D.B.H.	Ingrowth volume summa	ry per acre
Class (Inches)	Ponderosa pine	Douglas-fir
	Bd. ft.	Bd. ft.
3	eec ≃ee	
4	der rep	Will date
5	<u>3</u> / 0.00 . <u>4</u>	/ 85.25
6	cas oca	84.63
7	4/ 15.17	85.50
8	080 CGC	67.84
9	71.76	49.80
Total	86.93	373.02

^{3/} By referring to table 7, it will be seen that a five-inch ponderosa pine does not attain merchantable size in 35 years. 4/ Number of trees per acre times volume per tree.

The products derived are net values because average mortality has been deducted from pole volumes in the tables.

7. Obtain total volume of the stand 35 years after logging by summing the volume of residual trees and ingrowth. Computations follow:

Volume of residual trees at end of 35-year cutting cycle	8875	bd.	ft.
Ingrowth			
Ponderosa pine	87	11	11
Douglas-fir	<u>373</u>	11	79
Total predicted volume of stand 10" d.b.h. and larger at end of 35-year cutting			
cycle	9335	IŤ	11
Periodic annual growth			
3875 bd. ft. + 87 bd. ft. + 373 bd. ft. =	124	11	11
35			

LIMITATIONS ON USE OF TABLES

Two limitations of which the user should be aware apply to prediction of growth from these tables. One limitation pertains to species composition of stands. The stands studied contained, on the average, 77 percent ponderosa pine and 23 percent Douglas-fir by basal area. Hence, these tables should be used only for predicting growth of stands which are predominantly ponderosa pine. The other limitation applies to predicting growth in stands which have been cut two or more times. Growth estimates from the tables should not be applied directly unless growth in a cut-over stand has dropped back to about the pre-logging rate. If a stand is still benefiting from the stimulating effect of thinning caused by a previous logging, its initial growth rate at the time of the second cutting will be higher than the initial rate given in the growth tables. Therefore, the tables will generally underestimate growth after a second cutting. By adjusting for the higher initial growth at the time of second or later cuttings, the tables would be improved but the degree of improvement and the reliability of estimates would be unknown. The growth values in tables 1, 2, 3, and 4 should not be extended in order to permit prediction of growth in stands more heavily stocked than shown in the tables. It is probable that growth in more heavily stocked stands is influenced by stand density.

Table 1.--Volume per acre, Scribner rule, of ponderosa pine 1/ following selective cutting, by board-foot reserve stand classes, , average stand structure average site 2/

		Volume after an interval	an interval	of:			
5 yrs. 10 yrs. 15 yrs.	200	yrs. 25 yrs.	30 yrs.	35 yrs.	40 yrs.	45 yrs.	50 yrs.
Bd. ft. Bd. ft. Bd. ft.	Bd。	Bd. ft. Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.
1290 1460	16	1650 1820	2020	2210	2400	2590	2770
2400 2640	28	2890 3130	3380	3620	3860	4100	4330
3520 3820	41	4140 4440	4740	5030	5320	5610	2890
4640 4990	ಬ	5380 5750	6100	6440	6780	7120	7440
5750 6170	99	6620 7060	7460	7860	8240	8630	0006
6870 7350	78	7870 8360	8820	9270	9700	10140	10550
8000 8530	16	9120 9670	10140	10680	11160	11640	12110
9100 9710	10360	360 10980	11540	12100	12620	13150	13660
1.0220 10880	11600	12290	12900	13510	14090	14660	15220
11340 12060	12850	13600	14260	14920	15540	16170	16780

Average site index of basic data was 71 feet at 100 years, ranging from as low as 52 feet to as high All trees 9.6 inches d.b.h. and larger are included. as 92 feet.

Basis: 60 one-half acre plots.

^{3/} These are net values of growth obtained on residual trees only. Ingrowth is not included.

Table 2.--Volume per acre, Scribner rule, of ponderosa pine 1/ following selective cutting, by board-foot reserve stand classes, Site IV, average stand structure

	50 yrs.	Bd. ft.	2890	4480	0409	0994	9250	10840	12430	14020	15610	1.7200
	45 yrs.	Bd. ft.	2690	4230	2770	7320	8860	10400	11940	1.3480	15020	16560
	. 40 yrs.	Bd. ft.	2490	3980	5470	0969	8450	9940	11430	12920	14410	15890
of:	. 35 yrs.	Bd. ft.	2280	3720	2160	6600	8040	9480	10920	12360	13790	15230
an interval	30 yrs.	Bd. ft.	2080	3460	4850	6230	0194	0006	10340	Quart	13150	14530
Volume after a	. 25 yrs.	Bd. ft.	1870	3200	4530	5860	7180	8210	9840	11170	12500	13820
Volu	. 20 yrs.	Bd. ft.	1690	2950	4210	5470	6730	0664	9250	10510	11770	13030
	. 15 yrs.	Bd. ft.	1490	2680	3870	2060	6250	7440	8620	9810	11000	12190
	0 yrs.	Bd. ft.	1300	2430	3550	4680	2800	6920	8050	9170	10300	11420
99 08	5 yrs.	Bd. ft.	2/ 1120	2180	3240	4300	5360	6420	7480	8540	0096	10660
Volume	of cutting	Bd. ft.	1,000	2,000	3,000	4,000	5,000	000 5 9	000 % %	8,000	000 6	3.0,000

-7-

These are net values of growth obtained on residual trees only. Ingrowth is not included. All trees 9.6 inches d.b.h. and larger are included.

Basis: 60 one-half acre plots.

Table 3.--Volume per acre, Scribner rule, of ponderosa pine 1/ following selective cutting, by board-foot reserve stand classes, Site V, average stand structure

Volume	٥ ٥			Volume	after an interval		of:			
of cutting	; 5 yrs.	: 10 yrs.: 15 yrs	15 yrs.	: 20 yrs.:	25 yrs.:	30 yrs. :	35 yrs.:	40 yrs. :	45 yrs.	50 yrs.
Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.	Bd. ft.
1,000	2/ 1110	1270	1430	1610	1780	1960	2140	2330	2510	2680
2,000	2160	2380	2600	2840	3070	2300	3530	3760	2990	4200
3,000	3220	3490	3770	4070	4360	4640	4920	2200	5470	5730
4,000	4270	4600	4940	5300	5650	2990	6310	6630	0269	7260
2,000	5320	5710	6110	6540	6940	7330	0044	8070	8430	8780
000 49	6380	6820	7280	0222	8240	8670	9110	9500	0166	10310
7,000	7430	7930	8450	0006	9530	0266	10480	10940	11390	11830
8,000	8480	9040	0196	10230	10820	11350	11880	12380	12870	13360
000°6	9540	10160	10780	11460	12110	12690	13270	13810	14360	14880
10,000	10590	11270	11950	12690	13400	14040	14660	15250	15840	16410

These are net values of growth obtained on residual trees only. Ingrowth is not included. 1/ All trees 9.6 inches d.b.h. and larger are included. 2/ These are net values of growth obtained on residual

Basis: 60 one-half acre plots.

Table 4. -- Gross board-foot volume growth per acre of ponderosa pine residual trees, Scribner rule, following selective cutting 1/, by basal area reserve stand classes 2/,

average site quality and age

	yrs.	ft	02	0	0	000	0	09	Q	0	0	00	0
	20	Bd.	2030	2620	3200	3780	4370	4950	5540	6120	6700	7290	7870
	45 yrs.	Bd. ft.	1820	2360	2890	3430	3960	4490	5030	5560	6100	6630	7170
	40 yrs.	Bd.ft.	1610	2090	2570	3060	3540	4020	4510	4990	5470	2960	6440
of:	35 yrs.	Bd. ft.	1380	1810	2250	2680	3120	3550	3980	4420	4850	5280	5720
interval	30 yrs.	Bd. ft.	1160	1540	1920	2300	2680	3060	3440	3820	4200	4570	4950
Volume after an interval	25 yrs.	Bd. ft.	940	1260	1590	1910	2230	2560	2880	3200	3530	3850	4170
Volume	20 yrs.	Bd. ft.	740	066	1250	1510	1760	2020	2280	2540	2790	3050	3310
	15 yrs.	Bd. ft.	520	710	006	1090	1270	1460	1650	1830	2020	2210	2400
	10 yrs.	Bd. ft.	330	450	570	069	820	940	1060	1180	1310	1430	1550
	5 yrs.	Bd. ft.	3/ 130	190	250	310	370	430	490	550	919	049	730
Basal area of reserve stand	at time of cutting	Sq. ft.	10	15	20	25	30	35	40	45	20	55	09

To correct the values in this table for mortality, reduce by 15 percent or multiply by the conversion Basal area is computed on trees 9.6 inches d.b.h. and larger in the reserve stand. All trees 9.6 inches d.b.h. and larger are included. factor 85 percent.

Table 5.--Adjustment factors for effect of age and site quality

upon board-foot volume growth of ponderosa pine
following selective cutting

Average age	0	Ave	rage site	index	
(Keen class)	50	60	.70	. 80 .	90
	Percent	Percent	Percent	Percent	Percent
1.0	125	133	142	150	158
1.1	122	130	138	147	155
1.2	118	127	136	144	152
1.3	116	124	133	141	149
1.4	112	121	130	138	146
1.5	110	118	127	135	143
1.6	106	115	124	132	140
1.7	104	112	120	129	137
1.8	100	109	118	126	134
1.9	98	106	114	123	131
2.0	95	103	112	120	128
2.1	92	100	108	117	125
2.2	89	97	105	114	122
2.3	86	94	102	111	119
2.4	83	91	100	108	116
2.5	80	88	97	105	113
2.6	77	85	94	102	110
2.7	74	82	90	<u>99</u>	107
2.8	70	79	87	96	104
2.9	68	76	84	93	101
3.0	65	73	81	90	97
3.1	62	70	78	87	95
3.2	59	67	75	84	92
3.3	56	64	72	81	89
3.4	53	61	69	78	86
3.5	50	58	66	75	83
3.6	47	55	63	72	80
3.7	44	52	60	69	77
3.8	41	49	57	66	74
3.9	38	46	54	63	71
4.0	35	43	51	60	68

Table 6.--Volume 1/, Scribner rule, of pole-size ponderosa pine trees following selective cutting by d.b.h. classes, site quality IV (Site index

	50 yrs.	Bd. ft.	31	45	53	44	96	124	154
	40 yrs.; 45 yrs.;	Bd. ft.	2/ 28	40	55	72	92	115	144
of:	40 yrs.	Bd. ft.	1	32	46	64	83	104	134
interval	35 yrs.	Bd. ft.	!	27	40	24	74	94	118
after an	30 yrs.	Bd. ft.	ŀ	ì	28	45	63	81	104
Volume per tree after an interval of:	25 yrs.; 30 yrs.; 35 yrs.;	Bd. ft.	8	1 1	8	31	20	89	68
Volume	20 yrs.	3d. ft.	2 8	1	1	8 8	37	22	70
	15 yrs., 2	Bd. ft.	E 1	1 1	!	1	8 8	37	56
	O yrs.	d. ft. E	1	:	B 3	8	1	27	41
	5 yrs. 10 yrs.	Bd. ft. Bd. ft.	1	1	89 8	ł	# 0	!	27
D.B.H. class:			ಬ	4	ಬ	9	7		თ
D.B.H	of c	-							

Volumes in this table have been reduced by 5 percent to account for average mortality. Volumes are given for trees 9.6 inches d.b.h. and larger. 121

Table 7. --Volume 1/, Scribner rule, of pole-size ponderosa pine trees following selective cutting by doboho classes, site quality V (Site index 64)

		50 yrs.	Bd. ft.	2/ 21	30	42	56	7.1	26
		45 yrs.	Bd. ft.	1	26	38	52	29	98
	. of:	40 yrs.	Bd. ft.	9	19	32	48	64	88
	interva]	35 yrs.	Bd. ft.	ì	\$ 1	26	41	58	78
	after an	30 yrs.	Bd. ft.	Q B	1	19	34	20	69
	per tree	25 yrs.	Bd. ft.	B B	0	Name Cole	22	42	28
	Volume	20 yrs.	Bd. ft.	Catho Catho	i D	86 (25)	19	22	49
Composition Composition Composition		5 yrs. 10 yrs. 15 yrs. 20 yrs. 25 yrs. 30 yrs. 35 yrs. 40 yrs. 45 yrs. 50 yrs.	Bd. ft.	9	3	ı B	8	24	39
		10 yrs.	Bd. ft.		ou particular de la companya de la c	E E	!	8	37
		5 yrs.	Bd. ft.	0	f t	ĝ ĝ	å B	1	18
TT CT CT	D.b.n. class:	of cutting : (Inches)		1 1	വ	9	4	ω	G

 $\frac{1}{2}$ Volumes are given for trees 9.6 inches d.b.h. and larger. $\frac{2}{2}$ Volumes in this table have been reduced by 5 percent to account for average mortality. Volumes are given for trees 9.6 inches d.b.h. and larger.

Table 8.--Volume 1/, Scribner Rule, of pole-size Douglas-fir trees following selective classes, site qualities IV and V cutting in ponderosa pine stands, by d.b.h.

	. 50 yrs.	Bd. ft.	2/ 25	32	39	45	20	22	64	70	76
	45 yrs.	Bd. ft.		28	55	40	47	52	59	65	7.1
1 of:	40 yrs.	Bd. ft	g g	1	27	32	39	45	50	28	65
n interva	35 yrs.	Bd. ft.	1	ł	8	25	31	39	45	53	9
Volume per tree after an interval of:	30 yrs.	Bd. ft.	1	8 1	1	B G	27	32	40	48	22
e per tre	25 yrs.	Bd. ft	8	ŝ I	9.0	8	1	25	23	41	48
Volum	20 yrs.	Bd. ft.	1	E	8	0 8	8	0	27	\$	43
	15 yrs. 2	Bd. ft.	!	1	1	8	1	;	1 3	22	35
	5 yrs. 10 yrs.	Bd. ft. Bd. ft.	0 8	8 8	8 0	8 8	8		60		28
			1	1	8	. 8	8 8	8 ()	6	8 1 C3	21
D.B.H. class :	of cutting:	1	r-i	હ્ય	ಣ	4	Ω	9	7	ω	Ф.

Volumes in this table have been reduced by 5 percent to account for average mortality. Volumes are given for trees 9.6 inches d.b.h. and larger.



APPENDIX TABLES



Appendix table 1 .-- Height of dominant and codominant trees of average breast-height diameter 1/

	Age (years)					Height, by site index	by sit	e indez	1					
		40	20	09	02	80	06	100	110	120	130	140	150	160
		Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet	Feet
	20	9	6	12	16	20	25	30	35	40	45	20	55	9
	20.	11	15	20	26	32	38	44	51	24	64	20	27	84
	40.000000000000000000000000000000000000	16	22	28	35	42	49	52	63	20	24	82	93	100
	20°	21	28	35	43	21	58	65	73	80	88	46	105	113
		26	34	42	20	58	99	73	81	90	66	107	115	124
	70.000000000000000000000000000000000000	30	39	47	56	64	73	80	89	98	108	116	125	134
	80.	34	43	52	19	70	43	88	66	106	116	124	133	143
	000	37	47	22	99	75	82	94	104	113	123	132	142	152
CI	100.	40	20	09	20	80	06	100	110	120	130	140	150	160
-15														
5-	1.1.0	42	53	63	74	84	92	106	116	127	137	147	158	168
	120.	44	52	99	22	88	100	111	122	133	144	154	165	175
	130	45	22	69	80	92	104	116	128	139	151	191	172	182
	140.00000000000000000000000000000000000	46	59	7.1	83	96	108	121	133	145	157	167	179	189
	150	47	09	73	98	66	112	125	138	151	163	173	185	195
	160.00000000000000000000000000000000000	48	19	75	83	102	116	129	143	156	169	179	191	201
	170.00000000000000000000000000000000000	48	62	22	91	105	119	133	147	161	174	184	196	206
	180	49	63	78	93	108	122	136	151	165	179	189	201	211
	190.	49	63	62	92	110	125	139	154	169	183	194	205	216
	200	20	64	80	26	112	128	143	157	172	187	198	209	220
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1/ Meyer, W. H., "Yield of even-aged stands of ponderosa pine." U. S. Dept. of Agr. Tech. Bul. 630, 60 pp., illus. 1938.

Appendix table 2.--Site-quality classification for ponderosa pine,

with corresponding heights at maturity

in terms of logs. 1/

Logs in dominant trees		Site i at 100	Site quality class	
at maturity <u>2</u> /	Range	Central value		
Number	Feet	Feet		
10 or more 8 to 9 7 5 to 6 3 to 4 2.	+113 99112 8598 7184 5770 4356	120 106 92 78 64 50	I	
			V	

Meyer, W. H., "Yield of even-aged stands of ponderosa pine."
U. S. Dept. of Agr. Tech. Bul. 630, 60 pp., illus. 1938.

U. S. Dept. of Agr. Tech. Bul. 630, 60 pp., illus. 1938.

2/ Estimated in terms of 16-foot logs to 8-inch top. Maturity is assumed to begin at the age of 250 years.

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14	*List of publications available for distribution or loan, 1910 through 1947. NRM Station. June 1948.
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31	Publications of the Northern Rocky Mountain Forest and Range Experiment Station, 1912 through 1950. NRM Station. July 1951.

^{*}Out of print. Loan copies may be obtained upon request.